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To: Mr Mohamed Bashir Mohamud
General Manager
Baardheere Dam Project
P.O. Box 2807
Mogadishu
Somali Democratic Republic

12 December, 1988

Dear Mr Bashir,

BAARDHEERE DAM PROJECT

PANEL OF EXPERTS REPORT No. 7

We have pleasure in submitting our report incorporating the observations, conclusions and recommendations from the meetings which took place in Paris, at the World Bank Offices, from 6th to 12th December, 1988.

Section 2 of our report gives our main conclusions and recommendations on the Final Report and Tender Documents prepared by CIECC for the embankment dam, concludes that this alternative and the RCC dam are technically sound and comparable in cost and recommends that tenders be obtained for both.

Cont/...

On Monday 12th October we reported these findings to the Donor's meeting.

Respectfully submitted,

Pierre Londe (Chairman)

John Newbery

Ivor Pinkerton

Hans Bachmann

SOMALI DEMOCRATIC REPUBLIC

BAARDHEERE DAM PROJECT

PANEL OF EXPERTS REPORT NO. 7

Paris, 12 December 1988

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1. INTRODUCTION

The seventh meeting of the Panel was held in Paris, in the World Bank offices, from 6th to 12th December, 1988. The Panel was composed of four members : Pierre Londe, John Newbery, Ivor Pinkerton and Hans Bachmann, who joined the panel for the first time as an expert in the electro-mechanical field.

The main purpose of the meeting, which was attended by H.E. Minister Habib, BDP staff, IRBD and EEC representatives and CIECC, was to review and finalize the Final Report and Tender Documents prepared by CIECC for the embankment dam alternative. Some of these documents, in draft form, were sent to the Panel members prior to the meeting. In addition, at the request of BDP, the Panel was invited to compare the alternatives (the embankment dam and the RCC dam) in terms of technical feasibility and cost estimates, and to make recommendations on the tendering procedures.

A list of participants is given in Appendix A. A list of documents, presented to the Panel by CIECC and ELC, is given in Appendix B.

The Panel records its appreciation of the assistance rendered by the World Bank staff in Paris.

2. MAIN CONCLUSIONS AND RECOMMENDATIONS

2.1 The Final Report on Technical Design of the embankment dam alternative is comprehensive and generally endorsed by the Panel.

2.2 Improvements in the design are recommended mainly as regards the retaining wall arrangement for the power intake channel and the diversion tunnel control gates.

2.3 The scope and findings of the site investigations for the embankment dam alternative are considered adequate for the dam itself but generally the sites of the ancilliary structures - spillway, diversion and power - are essentially unexplored. Consequently subsurface conditions there are inferred leading to inevitable uncertainties. These should be clarified by an exploration programme early on the main contract if this design is built.

2.4 The cost estimates for the embankment dam alternative have been reviewed and are considered to be realistic.

2.5 Comments are made on the Tender Documents and Technical Specifications with a view to improving the quality of the works and better controlling the cost.

2.6 Some comments and suggestions on the technical specification of power plant equipment are given but they should not affect the general layout.

2.7 The thorough review of the two alternative designs (embankment dam and RCC dam) lead to the conclusion that they are both sound. The cost comparisons are made difficult by the fact that the dams are of different types and the evaluation teams are from two different consulting engineers. However, the Panel is of the opinion that, for all practical purposes, the costs of the two alternatives are the same.

2.8 In view of the above conclusion it is strongly recommended to proceed with tendering for both alternatives.

3. FINAL REPORT ON EMBANKMENT DAM ALTERNATIVE

3.1 General

At the beginning of the meeting, the following volumes were handed over to the Panel by CIECC:

- Final Report on Technical Design
- Attachment (I, II, III)
- Annex I : Core samples and logs
- Annex II : Building materials

- Annex III : Lab. tests on impervious soils
- Annex IV : Hydraulic model tests
- Annex V : Cost estimates
- Drawings

Most of the material included in the above documents had been already reviewed by the Panel in the previous meetings. The fact that the main recommendations made then have been incorporated is acknowledged. However, some significant comments were not taken into account. These include:

a) The effect of clay seams in the rock foundation of the main dam has not been fully investigated, as no excess pore pressure has been included in the stability analyses. Measures should be provided for relieving the excess pore pressure such as a pattern of drilled holes.

b) The gate shaft of the bottom outlet has not been moved closer to the dam axis as recommended. This would have given a more convenient arrangement for access but the present location of the shaft is acceptable.

c) The "City Gate" shape for the bottom outlet tunnel is maintained. With this arrangement external water pressure could damage the lining when the tunnel is drained for inspection and maintenance during operation. Special design measures will be necessary to ensure this does not occur.

d) The spillway chute alignment has not been made shorter but the present alignment is satisfactory.

e) The power intake has not been moved so the foundation requirements of the high retaining wall have not been satisfactorily solved. The Panel suggest that a movement

of the intake structure about 20 m laterally further into the abutment would considerably improve the design without increasing the length of the penstacks.

f) Some high and steep cuts are still shown in areas where there is a possibility of inadequate rock quality for such cuts.

The above points are discussed further in this report, particularly in sections 3.2 and 3.6.

3.2 Geology

Information on geology is contained in the Final Report and annexes as follows:

Final Report - Chapter V - Geomorphology and Engineering Geology
Annex 1 - Geologic Report
Annex 1-1- Geologic Report - Album of Core samples
Annex 1-2- Geologic Report - Logs of Boreholes and Pits

Chapter V is a synthesis of the more detailed information contained in Annex 1.

A similar presentation of this information was made to the Panel in July during their visit to Mogadishu. A detailed review of that data was made in Panel Report No.5. Consequently only a few key topics will be discussed in this report.

The CIECC report describes in more detail than earlier reports the superficial deposits overlying bedrock as their nature is more relevant to the design of an embankment dam. Two main types of deposit are present - alluvium and colluvium - both of which can be subdivided

according to their constituents. Colluvium is an internationally used term and should be substituted for the terms "deluvium" and "eluvium" in Annex 1. Deluvium is an archaic term referring to glacial desposits and elevium to wind blown deposits.

Weathering is a very important topic as it controls the depth of excavation to foundation level for the various engineering structures and the angle of cut slopes. Thus most engineering sections in the Tender Drawings show two lines:

-xx- Lower boundary of highly weathered

-x- Lower boundary of moderately weathered

the first in marl, the second in limestone.

Annex 1 does not give a description of the weathering scale used at Baardheere. The boundaries are based on the logs of the four A and fourteen B holes which use the following weathering scale:

Grade	Description	International Scale
A1	Sound	Fresh
A2	Slightly weathered (iron-stained joints)	Slightly weathered
A3	Medium weathered, matrix slightly altered	Moderately weathered
A4	Deeply weathered, matrix deeply altered	Highly weathered
A5	Totally weathered, argillified rock, fabric essentially destroyed	Completely weathered to residual soil

To the right of this table are given the equivalent weathering grades used in the International Scale. As in Panel Report

No.5, it is recommended that the International Scale be used at Baardheere following the descriptions used for grades A1 to A5. Two boundaries should be shown on sections "highly weathered" and "moderately weathered" - and other terms such as "strongly" and "medium" changed. As the boundaries are extrapolated long distances from the nearest boreholes the Panel strongly recommended that the word "inferred" be added i.e. "lower boundary of highly weathered - inferred" otherwise an unwarranted degree of accuracy could be placed on these boundaries. The need for an exploration campaign early in the construction programme to obtain more information at certain key locations has already been stated in Panel Report No.5.

Cut slopes have been discussed in previous Panel reports and the recommendation made to go for flatter slopes. The Panel is pleased to note that generally the Engineer has accepted this recommendation, e.g. for the high power station cut. In sound fresh rock slopes of 1H:2V are considered appropriate with 5 m berms and 10 m height between berms. Where discontinuities are favourably oriented the lower-most cut could be steepened to 1H:3V. In weathered and loosened limestone slopes of 1H:IV are recommended. Finally in highly and completely weathered marl, residual soil and superficial deposits a cut slope of 2H:1V is appropriate. On some of the tender drawings steeper slopes are shown and this aspect needs to be reviewed by the Engineer.

//

Minor geological defects are often very important at dam sites especially weak seams in horizontally bedded sediments. In the marl at Baardheere three conditions are present:

(i) slickensided discontinuities
(ii) smooth planes in grey argillaceous marl
(iii crushed clay seams

In Annex 1 reference is made to a "crushed zone" in the riverbed from El.85 to El.45. This should be amended to indicate the presence of the three types of weak partings (listed above) between those elevations.

In the vicinity of the retaining wall between the dam and the intake structure extremely weathered and fractured material i.e. completely to highly weathered marl, was recovered in drill hole B9 at and below proposed foundation level for the wall. Clay seams are also present in B10, B11, and B12. It is noted that the wall will be perched on a narrow column of rock. On the river side the colluvium and weathered marl will be stripped while on the upslope side a vertical cut 16 m high formed. Even if the remaining column of rock was free of defects, such as clay seams, stress relief would cause discontinuities to open up and weaken the rock mass despite the proposal to pin it together with anchor bars. The Panel repeats its conclusion given in Report No.5 that a lower level for the retaining wall will be necessary.

3.3 Materials

3.3.1 Core Material

The location of the borrow areas for the core material is shown on the tender drawings together with more detailed plans and sections. The anticipated thickness of usable materials is also given. This thickness varies from slightly less than 2 m up to 3 m in places. The amount of overburden is generally around 0.5 m but slightly more in some areas. No information is given on in situ moisture contents but should be included if it is available. We are satisfied that an adequate quantity of material is available in the borrow areas for the construction of both the cofferdam and the main dam. The material in these borrow areas has generally a CL classification with properties suitable for use as a core material. A limited amount of laboratory testing has been done to establish the relevant properties. It is usual to issue to tenderers supplementary information on the construction materials. This information would include all the results of the laboratory testing. The Panel recommends that this supplementary information on construction materials be prepared and issued to the tenderers with the tender documents or alternatively made available on request.

3.3.2 Filter Materials

The filter zones now incorporated in the embankment design are :

- a single filter zone 3 m wide on the upstream side of the core which is designated Zone 4.
- a fine and a coarse filter zone each 3 m wide on the downstream side of the core which are designated Zone 2 and Zone 3 respectively.

This arrangement of filter zones is in accordance with the recommendations in the last Panel report and is satisfactory.

The material to be used in these filter zones will consist of a blend of natural river alluvial sand and processed sand obtained from quarried limestone. The grading limits for the filter materials in the various zones are shown on the tender documents. These limits are generally satisfactory.

3.3.3 Quarried rock

Rockfill for the outer shells of the dam will be obtained from required excavations and from a quarry in oolitic limestone immediately adjacent to the damsite. For estimating purposes CIECC have assumed that 70% of the rockfill will be obtained from the required excavations and 30% from the quarry. The amount of rockfill that will have to be quarried may be slightly higher than the 30% estimated by CIECC. The variation in the amount of rock to be obtained from the quarry will not affect the time for the construction of the dam but could slightly affect final costs. The final ratio of the amount of rockfill to be quarried and the amount that will be obtained from required excavations will only be available when the construction is completed.

Adequate quality rockfill will be available from the quarry. However, great care will be necessary to ensure that only acceptable quality rockfill is directed to the dam for the material obtained from required excavations.

The grading limits for the rockfill shown on the tender drawings are satisfactory. Provided the rockfill is free draining and of adequate visual quality slight departures from these grading limits would be permissible. Gradation tests for rockfill

control are often difficult and time consuming because of the large particle sizes involved. Normally only a limited number of tests are done to establish satisfactory visual control.

3.4 Hydraulics

3.4.1 General

Baardheere Reservoir will be operated with the maximum operating level at El 141.9 which is 3.6 m below the spillway crest level and all floods up to a return period of 1 in 100 years will be passed through the bottom outlet. For floods of higher magnitude the bottom outlet will be closed and the flood discharges will be passed through the spillway. The maximum permissible discharge downstream will be 700 m3/s for the inflow flood of 1 in 100 years with peak inflow of 1194 m3/s. For actual operation some of this discharge would be passed through the power station so the discharge through the bottom outlet would be 500-600 m3/s. The maximum discharge through the spillway will be 1766 m3/s which corresponds to an inflow flood of 1 in 10,000 year recurring period. Model studies have been carried out for both the spillway and the bottom outlet/diversion tunnel.

3.4.2. Spillway

The hydraulic conditions observed in the model study for the approach channel and spillway chute are satisfactory. The flip bucket at the end of the chute is set at an angle of 60° with the centre line of the chute and is horizontal at an elevation of 107 which is above the tailwater level. No detailed information is available on the geological conditions in the flip bucket/plunge pool area except that the bedrock is expected to be marl and that surface weathering could extend to some limited depth of say 5 m or slightly more. For the model study using erodible material in the plunge pool area the deepest level of erosion was El 93. The tender drawings show a flip angle of 25° and radius of the flip bucket of 15 m. A vertical cut-off sill at the downstream end extends down to El. 90, some 17 m below the flip bucket level. This level is slightly lower than the expected depth of scouring in the plunge pool area. The excavation for the construction of this deep cut-off wall will be difficult. It is more usual to provide a sloping concrete wall protection anchored to the rock. It is not proposed to do any excavation of the marl to form an initial plunge pool.

From the photographs of the model study the angled flip bucket appears to give reasonable hydraulic conditions after the plunge pool has been excavated by flood discharges. The setting of the flip bucket at a horizontal angle to the chute alignment does not deviate the flow towards the river as the end of the chute and the flip bucket are not super-elevated. Considerable erosion of the river bank would be therefore expected during flood discharges. This would not be expected to affect the satisfactory operation of the project although the coarser eroded material from the river bank and plunge pool, particularly during the first discharge, would probably be deposited in the river channel. The finer material would be carried further downstream. The rate of erosion of the plunge pool will depend on the rock conditions and this would affect the extent of bank erosion occurring during the early spillway discharges. As the spillway will only operate on rare occasions for the flood flows exceeding the 1 in 100 year return period we consider the arrangement acceptable.

3.4.3. Bottom outlet/diversion tunnel

Initial model studies showed unsatisfactory hydraulic transient conditions occurring at the central section

of the diversion tunnel where there are two intermediate piers with the radial gate installed. These conditions would occur as the discharge increases from the low flows with open channel flow conditions to the higher discharges when the tunnel flows full. These unsatisfactory conditions have been eliminated by using the radial gate for controlling discharges during river diversion. This situation is most unusual and will require very close attention during river diversion floods. Floating timber carried into the tunnel could be trapped in this central section and affect the passage of flood flows. The alternative arangement would be to make provision for river closure at the upstream end of the tunnel and install the radial gate immediately downstream from the tunnel plug after closure. With this alternative arrangement the full tunnel cross- section would be available for river diversion except for the upstream intermediate gate pier. This alternative arrangement is the more usual but would involve more time for the installation of the radial gate <u>after</u> the diversion tunnel is closed. Some temporary arrangement for water releases would be necessary before the permanent facilities in the bottom outlet are available. The amount of these temporary releases is not known but probably is in the order of 5 m3/s.

Dissipation of energy at the downstream end of the tunnel both during river diversion and for the later discharges from the bottom outlet are satisfactory.

3.5 Cost Estimates

Most of the comments made in our previous reports (5th Meeting, July 1988 and 6th Meeting, October 1988) remain valid. We still consider that some quantities might have to be increased during construction owing to unknown rock conditions (see section 3.2). It is possible that more than 30% of the rockfill will have to be quarried. Nevertheless, we consider the cost estimates proposed by CIECC to be satisfactory. We therefore accept the total cost of 196 million dollars - covering the civil engineering works, with a 4% escalation rate up to the completion date - as being realistic.

3.6. Miscellaneous Comments on Drawings

Geology

The Tender Drawings contain seven drawings illustrating site geology -one plan (no. 1101) and six sections (nos. 1102 to 1107).

As mentioned in section 3.2 the weathering boundaries need to be standardised to "highly" and "moderately" with "strongly" and "medium" deleted.

Borehole numbers should be added to the sections and, where holes have been projected, this should be stated.

Summary logs of boreholes should be included in the drawings in a similar manner to those in the documents prepared by ELC i.e. both in columnar form and on sections. Reference should be made to the availability of additional factual geological investigation data, such as detailed logs, in the office of BDP. This aspect is discussed below in section 4.4 on supplementary information.

The ELC documents contain two plans showing reservoir geology. These could usefully be included in the drawings for the rockfill design.

Core Trench

Sections through the core trench in the abutments show the trench slopes at 1H:3V which is considered too steep, not because of slope stability but differential settlement of fill. 1H:IV or possibly IH:2V is preferred.
The requirement that the finished foundation surface should be excavated to the lower limit of moderately

weathered rock extends right across the valley for the width of the core trench, not just the upper right abutment.

Spillway and Power Intake Retaining Walls

The spillway and power intake mass concrete gravity retaining walls do not appear to have been designed for the "at rest" condition and should be modified. This would modify the sloping face of the retaining wall from 0.5H to 1.0V to about 0.8H to 1.0V. The power intake retaining wall is founded on a relatively narrow ledge of rock which could be shattered and loosened by the excavation on either side and possible stress relief. This problem for the power intake could be overcome by locating the power intake and approach channel slightly further into the abutment. This would not make any significant change in the length of the power conduits but would slightly increase the quantities of excavation.

Spillway flip bucket cut-off

The excavation for the cut-off at the flip bucket is some 17 m deep in marl. This excavation will be difficult and the rock against which the concrete cut-off is placed [illegible] would be shattered and loosened. A sloping cut-off would

avoid this excavation and is more commonly used for a flip bucket/plunge pool arrangement.

Foundation piezometers

Foundation piezometers (electric cells) are necessary to establish pore pressures particularly downstream from the grout curtain.

4. TENDER DOCUMENTS FOR EMBANKMENT DAM ALTERNATIVE

4.1 General

A draft copy of Tender Documents was sent by courier in mid-November by CIECC to the Panel members. Unfortunately the delivery time was not quick enough to allow the comments made by the Panel to be incorporated before this meeting. We therefore repeat here the comments made in November, with some additions and amendments resulting from discussions among the Panel members.

The following comments cover:

Volume 1. Tender and Contract Conditions
Volume 2. Technical Specifications

We have no remarks on Volume 2, Tender Forms, except for Special Schedule 6 - exchange rates, covered in the corresponding items of Volume 1.

We have restricted ourselves to points which are most significant.

4.2. Technical and contract conditions

VOLUME I

Invitation for Tender - page 1

The Civil Works shall consist of an embankment dam" implies that there is no other alternative, which is not true.

Instructions to Tenderers

IT-1.A "constructing, completing and maintaining" for how long a period of time?

IT-5.A.3 Currency conversion at the rates prevailing 30 days prior to the Tender submission. Does this mean that it is a fixed rate condition for the whole duration of contract?

IT-6.B.5 The preliminary Programme of Works has to comply with the programme specified in SC.43.1. Refer to our comments on the latter clause.

IT-6.D. The RCC dam alternative "involves the basic design of the Works". According to this clause RCC cannot be considered.....

IT-17 not complete and IT-18 missing (2 pages missing).

Part I - General Conditions

GC.11.1 "The Contractor shall be deemed to have based his Tender on the data made available by the Employer..." This statement is more reasonable than the wording of GI-14 (see below).

GC.67.3 The Rules of Conciliation and Arbitration of the International Chamber of Commerce, recommended in this clause, are definitely more attractive for International Tenderers, than the Somali Supreme Court stipulated in the clauses SC-5.1 (b). This change is likely to result in an overall increase of the contract cost.

GC.72.1 This cause stipulates the use of a fixed rate of exchange for foreign currencies. It may however be advisable to amend it, through a Special

Condition providing the possibility of adjusting this rate periodically. This would relieve the Contractor from a financial risk and result in a more advantageous contract cost.

Part II - Special Conditions

SC-4.1(2) We propose that (iv) monitoring instrumentation should be added as "Specialized Works".

SC-6.7 The large number of drawings and the corresponding design studies left with the Contractor are not covered by a particular Bill item. This should be made clearly.

SC-6.7(c) last paragraph of (iii)

Read "if such details" instead of "because such details."

SC-8.3 The English of this clause should be improved. Not clear.

SC-14.2(b) How to reconcile a "revised" schedule with the contractual dates of SC-43.1?

SC-20.4 The English of this clause should be improved. Not clear.

SC-43.1 It is difficult to agree with the statement that "failure to meet the specified dates.... shall be a breach of contract". The Contractor does not have to meet all the dates of such a detailed programme, the actual date depending on the construction methods and eqipment. Only a few critical dates are meaningfull such as River Diversion, Start of Impounding, Basic Completion of the Works.

SC-43.1(a) The mention of "from 1st October of the first year" should be deleted as it is not a contractual date. It may be delayed for many reasons, which should not invalidate the Contract.

As compared to the previous bar-chart construction schedule, discussed in our meeting of October 1988, it is interesting to note that the diversion works are given about 6 months more time, together with the excavation for the main embankment. This is a correct change following at least partly the Panel's recommendation. However the Powerhouse is still on the critical

path and it is very doubtful that the concreting of superstructure could be carried out in the extremely short time allocated. It is also noted that the overall construction time has been extended by half a year, allowing a more reasonable time for a programme which at the moment has practically no float.

It is obvious that the construction schedule should be discussed and finalized with the Contractor, during the negotiations and prior to the award of the Contract.

SC-43.1(b) The times provided for ordering, manufacturing and shipping of the equipment (such as between HE.1 and HE.2, between HE.5 and HE.6, between HE.9 and HE.10) are too short.

Similarly between HE.15 and HE.16 with, in addition, an extremely short time for design.

SC-43.1(e) In the event of a 3 months (or even less) delay it is obvious that the Contractor would not meet some of the dates of the construction schedule.

SC-47.1 Any money paid by the Contractor according to this clause cannot be considered as a "liquidated

damage" except CW-18, which is the only one corresponding to a "damage" for the Employer. All the other items would be considered as "penalties" by any arbitrator or court.

In this respect it would be worthwhile to discuss the possible occurrence of delays for several items and no delay (or even advance) of the completion date.

This clause, as worded at present, is likely to increase the actual cost of the Contract.

Local Conditions

LC-1.B(2) & (3)

Some freedom should be given to the Contractor, as the temporary works and particularly the care of water during construction are his responsibility. He may propose satisfactory alternatives.

LC-1.B.(6) All the figures given in LC-1 are doubtful at this stage (particularly so in the concrete volume of 37,200 m3 stated here for the water delivery system).

General Information

GI-14 It is not fair (although done in many contracts) to state that "BDP does not take any responsibility" for the conclusions stated in the geological and geomechanical reports. This would not hold in a court, considering that BDP spent about 15 years studying the site, with the help of knowledgeable specialists, as opposed to the few weeks made available to the Contractor. Whatever the wording of such a clause the Employer takes the actual responsibility of the geological conclusions, just as he takes the responsibility of the design.

4.3 Technical Specifications

VOLUME III

PART I

1.6 The international system of units (SI) leads to the use of kilopascal (kPa) and megapascal (MPa) for pressure or stress (instead of kg/cm2). Similarly newton (N) should be used for forces (instead of kg which is not a force but a mass.

5.1. It is suggested that the following sentence: "Any modification requested by the Contractor thereof during construction period shall be approved by the Engineer"
should read
"Any modification requested by the Contractor should be approved by the Engineer"

It is somewhat questionable that the "check flood" (of 100 year return period) results in overtopping of the U/S cofferdam (132.1 vs 132.0 masl).

5.2. The establishment of a flood-forecast system is a delicate operation which, in the Panel's opinion deserves a special payment. Otherwise it is likely that a "cheap" and therefore unreliable system would be used. It would be preferable to have it designed by the Engineer rather than by the Contractor.

5.3. The end sentence of the first paragraph is not clear and needs rewording.

5.4. The design and construction of the closure dykes are typical of what is the full responsibility of the Contractor. He has to make a detailed

proposal for the approval or otherwise of the Engineer.

5.5. Some reconnaissance drilling or trenching should be carried out in the floor of the foundation pit, so as to make sure that a clay seam of some extension is not present at a shallow depth under the embankment.

6.1-C-3 It is debatable that quarried material should be obtained by the Contractor "at his own expense". This lack of flexibility in establishing fair prices is likely to result in an overall increase of cost.

6.4-C Blasting... controlled so that peak particle velocity shall not exceed the values given below:

max. p.p.v. (mm/s)	age of concrete (days)
0	up to 2
15	3 to 14
25	7 to 28
40	after 28

6.4-E "The responsibility of stability of excavation always remains at the Contractor's charge". This statement does not hold in cases where the

drawings show an excavation slope designed by the Engineer and possibly too steep for the local rock conditions or jointing.

7.5 Sub-clause B is missing.
Clause number, given in reference, also missing.

8.2 Forces should be given in kN, not in kg.
(for instance: 14,000 kg = 140 kN).

8.2.F It is not clear why the support by the steel ribs is not paid separately whereas the support by rockbolts is (compare with 8.2-G).

9.4 Bentonite shall be used to obtain stable mixes.
It should be mentioned in the specifications as a basic material for grouting.

9.5B Grouting, drilling machines ... percussion type with water flush

9.5-C-6 Automatic pressure recorders shall be specified.

9.6-B Maximum depth 90 m.

9.6-C Larger diameters are recommended for drain holes (3" and 4" instead of 2" and 3", or even 4" only).

9.6-E Long base extensometers, installed in boreholes are recommended for monitoring any potential displacement due to clay seams. Porepressure cells can be installed in 100 mm dia. holes. Extensometers call for 100 mm holes as well.

9.8-C We do not consider it necessary to use 3:1 mixes. Starting with 2:1 mixes would be satisfactory and efficient.

The Table giving the water/cement ratio vs Lugeon Units and Grout Takes is less than a ""guide". It has no practical meaning and should be deleted.

9.14-D Color photographs should be specified for all core boxes.

10.5A Standpipe piezometers in foundations under the dam (5 No.). The Panel prefers electric cells installed at greater depths.

10.8 Underground water observation - level and temperature with automatic gauges at 8 locations The Panel considers that standpipe piezometers will be adequate and that they can be dipped initially weekly and later on monthly.

14.5-G Equivalent standards are acceptable.

14.11 Clean up of horizontal contruction joints should be specified. This clean up is usually specified using a high pressure air/water jet applied before the concrete has hardened.

14.12-C-3.a Please check the figures of the Table.

14.12-C-3.b The 4 mm undersize for test seems too severe for practical purposes.

14.15-B It may be advisable to adjust the concrete placing temperature to the air temperature at time of placement. 30°C is probably too high in the hot season.

14.15-B-5 It is not necessary to cool the top surface by "free-flowing water". See 14.21.

14.19-B-4 The F.4 finish should be applied to the spillway chute, although the invert will be partly unformed.

14.22 Something is missing in the clause. Please give the definition of the Deviation Coefficient (in terms of mean and standard deviation).

15.1-A-5 The ± 150 mm tolerance is very severe for practical purposes. Why not specify only: "The dimensions shall not be less than those shown on the drawings"?

16.1-C The English of the sentences following the words "The Engineer will express..." should be improved, so as to be fully understandable.

16.2-D Grading limits 25 mm to 700 mm do not agree with the limiting curves shown on drawing BED-T-1218. The grading limits shown on this drawing are acceptable. It is not necessary to limit the fine size to 25 mm provided the rockfill is free draining. The maximum size is often that which can be encompassed in the layer thickness. In this case it would be 800 mm on the layer thickness.

16.4-E The specifying of screening for quarried or excavated material prior to placing in the shell zones is unusual. Such screening requires double handling and is expensive. Material from the quarry would normally be placed directly in the rockfill zones without screening. Unsuitable material from the quarry is normally wasted.

16.6-B The limiting of the surface of the outer shell zones to not more than 2 m above or below the inner shell zone is not necessary. It is often convenient for the outer shell zone to be at a considerably different level above or below the inner zone immediately adjacent to the filter zones. For such cases limiting slopes of the rockfill for differential heights would be 1.5 H: 1.0 V.

16.6-C4 The layer thickness of the filter material is usually more than for the core material. In this case a 400 mm layer thickness would be appropriate.

16.7-A(end) The protection width of 3m is too generous. A width of 1.50 m or 2 m would be adequate.

16.7-B-2-a(3) 5959 kg = 60 kN, etc.

16.7-C This section requires the contractor to make compaction control tests so as to finalize the relevant most favourable compaction procedures. However, for bidding purposes the following number of passes are usually specified. The number of passes may be varied after trials up or down usually with no variation in price.

Compaction of Core - It is usually expected that 8 passes of the specified tamping roller will be required to achieve adequate density.

Compaction of filter material - normal requirement is for 2 to 4 passes of a smooth drum vibrating roller conforming to the specified requirements.

Compaction of rockfill - Compaction is almost always specified to be 4 passes of a smooth drum vibrating roller conforming to the designated requirements.

16. B It is more usual to give a range of moisture content for the core material that will be expected to be used but to indicate that the Engineer reserves the right to vary the moisture

content. The permitted range of the moisture content is usually 2% (as specified here). It is suggested that the specified range be optimum to optimum plus 2%.

16.8.C Disc harrowing of innermost rockfill zone adjacent to the filter zones is not necessary and should not be specified. Bonding between layers in rockfill is obtained merely by placing each layer on top of the previous layer and compacting. Segregation of rockfill immediately adjacent to the filters is often avoided by placing the rockfill in thinner layers within a distance of 5 m from the filters. In this case a layer thickness of 400 mm would be satisfactory using selected finer rockfill.
Segregation in the outermost rockfill zones is not important for either strength, density or free draining properties.
The addition of water to the rockfill is not necessary in this case as absorption of water would be very small. This requirement should be omitted.

16.9 The sloping faces of the construction joints in the rockfill should be limited to 1.5 horizontal to 1 vertical. In the core and the filters the

sloping faces of transverse joints should not be steeper than 2 horizontal to 1 vertical.

16.10 The frequency of making control tests on the various materials placed in the dam should be specified. Suggested frequencies are as follows:

Core material - moisture and density tests, 1 test every 2000 m3 placed; permeability test, 1 test every 20,000 m3 placed.

Filter material - density and gradation tests, 1 test every 2000 m3 placed.

Rockfill - density and gradation tests, 1 test every 100,000 m3 placed.

The above frequency may be varied at the direction of the Engineer.

Quality control tests on the material in the stockpiles should not be necessary as material would be sent separately to waste or to stockpiles for re-use depending on its quality when talen from required excavations. Visual classification for rockfill adequacy is normally sufficient.

17.2 The specification of ± 1,5% from optimum should indicate whether it is the Standard Optimum or Modified Optimum.

1.3-A.6 The time mentioned for design and preparation of detailed drawings is short, as mentioned above.

1.3-A.11 Write 0.26 MPa instead of 2.6 kg/cm2, etc.

1.4-A The "standards specified herein" or "equivalent".

1.8-A The design criteria (maximum design displacements) should be given to the Contractor for a correct dimensioning of the expansion joints.

4.4 Supplementary Information for Tenderers

A limited amount of information on the geology of the site and the geotechnical data on the construction materials is included in the tender documents. Additional more detailed geological and geotechnical data obtained from the site investigations and laboratory tests should be made available to tenderers as supplementary information. Alternatively the tenderers could be advised that this more detailed data is available for their reference.

Also only a very limited amount of meteorological and hydrological data is included in the tender documents. More detailed information could be issued as supplementary information to tenderers or they could be advised that it would be made available to them on request.

5. POWER PLANT

5.1 Effect of longer power conduit on turbine regulation.

One major effect of the embankment dam alternative on the electromechanical layout is to roughly treble the length of penstocks (from 65m to 200 m or more). ELC made calculations on power unit regulation performance based on the original short penstock to obtain the required flywheel effect of the generator rotor. If not yet done, there should be a similar investigation for the longer penstocks. The longer penstocks could result in the need for higher generator inertia to maintain full stability of the insulated power system even on minimum head conditions.

5.2 Stacking of generator rotor core, assembly bay

Since the generator rotor core (estimated mass approx.90 t) cannot be transported it will have to be stacked on the assembly bay. The floor of the assembly

bay should have an opening to allow the generator shaft to be lowered into.

There should be enough space on the assembly bay to allow the generator rotor and stator to be assembled at the same time.

It is advisable that below the assembly bay there should be a room within the reach of the power house cranes for storage of heavy spare parts.

5.3 Type of turbine

ELC and Lahmeyer discarded the propeller turbine alternative from the beginning without giving it much consideration. The propeller turbine has some advantages compared to the Kaplan turbine, including:

Simpler design of turbine runner with fixed blades

No rotating servomotor and no oil supply to it through the shaft for runner blade control.

No feedback of runner blade position to turbine governor.

Simpler turbine governor without double regulation;

Therefore easier maintenance for operating staff in a developing country.

Therefore also cost reduction.

Therefore the Panel recommends that a comparison be made between propeller and Kaplan turbine for various loads and heads, as was done between Kaplan and Francis turbines. The main disadvantage of the propeller turbine, which is giving poor performance on low load, should not weigh too much with 4 units available to meet the total required station output.

The outcome of this comparison will in no way affect the design of the power house, since the main dimensions of both turbine types are equal.

It is worthwhile to mention that the only drawing showing monitoring details (even minor ones) of the machine (original ELC Nr. 2143) indicates a turbine and a governor with single control only, that means a propeller turbine.

5.4 Minor Comments

Although of small importance at this stage of the project, the following items should be brought to attention:

Turbine and generator bearings as well as the turbine governor oil tank should be provided with oil vapor exhaust and (eventually) with oil vapor sealing air.

Upper generator bearings as well as governor oil feeder to runner blade servomotor must have electric insulation barriers to prevent the flow of shaft current.

Combined thrust and guide bearing: location of oil to water heat exchanger outside the bearing housing should be a permissible alternative.

As an alternative to the specified natural oil circulation also forced oil circulation by self pumping action of the thrust collar should be allowed.

Generator fire protection: CO_2 - exhaust should be provided, so that after a discharge no greater amount of gas could find its way down to the turbine pit.

No PMG would be necessary for a modern type of turbine governor. The speed signal to the electronic part of the regulator would be given by a speed detector.

Excitation transformers and unit service transformers which are installed indoors should be of the dry type for safety reasons.

Cooling of static excitation equipment should be done with a closed air circulating system and air to water heat exchanger in order to avoid accumulation of dirt on delicate electronic equipment

All current transformers for measuring and protection should have 1 A secondary rating.

As an alternative to the proposed electro-mechanical protection relays a modern kind of electronic generator and power line protection system should be considered.

Power station auxiliary services: two sets of batteries of 220V would be advisable, no separate system neither 380 V ac nor 220 V dc for the switchyard seems necessary.

For the 220 kV switchyard combined voltage/current transformers would allow a more simple layout and cost reduction.

Voltage/current transformers should be provided also on the high voltage side of the generator feeders.

No voltage transformer would be necessary on the busbars.

Earthing switches on 220 kV-busbars are recommended.

220 kV-circuit breakers: since the high shortcircuit interrupting capacity of SF6-breakers is not needed in this case the alternative of small-volume-of-oil-type breakers with motor loaded spring action would be worthwhile to consider. They would give a minimum of problems in a developing country.

6. COMPARISON BETWEEN EMBANKMENT AND RCC ALTERNATIVES

6.1 General

The comparison between two alternatives involving two distinct dam types is a difficult exercise, as it has to take account of a number of parameters which are not strictly comparable. Thus safety concepts are different, the impact of geological and hydrological uncertainties are different, the unit costs apply to different materials and construction methods, the international competition is not similar for different dam types.

These difficulties are vastly aggravated when two different consulting engineers, as it is the case for Baardhere project, have prepared the alternative designs and specifications.

The Panel had therefore to endeavor to make a thorough analysis of the various components of both alternatives aiming at disclosing potential differences in cost and contingencies, so that a proper decision could be taken as regards the implementation of the scheme. As it will be shown in the following sections, the embankment alternative and the RCC alternative are practically equivalent and both should be called for tender.

6.2 Relative Merits and Drawbacks

In this section we present a check list of merits and drawbacks of each alternative, without taking the cost into account as the cost estimates are discussed separately in section 6.3.

a Embankment Dam

a.1 Merits

a.1.1 Conventional design : central core rockfill dam of moderate height

a.1.2 Use of a substantial part of rock excavation for the rockfill

a.1.3 Core material available at short distance

a.1.4 Ungated spillway.

a.2 Drawbacks

a.2.1. Large amount of alluvium deposit to be excavated for founding the main embankment on rock.

a.2.2 High upstream cofferdam, founded on low density sand

a.2.3 Sensitivity to overtopping during construction (and after)

a.2.4 Problems of stability of high cuts.

b. <u>RCC Dam</u>

b.1 Merits

b.1.1 Limited volume of excavation

b.1.2 No problems of stability of high cuts

a.2.4.) provided they are made flat enough and properly supported. This has to be taken into account in the quantities, as recommended by the Panel.

The RCC is a new technology (item b.2.1.) but more and more dams are built with it in the world. It is interesting to mention that most of these dams were successfully built by contractors who had no previous experience.

6.3 Cost Estimates

a. Embankment Dam

Further to our comments of section 3.5 we accept the cost estimate presented by CIECC although there are some components of the scheme which are still uncertain as far as rock conditions are concerned.

For the sake of comparison we therefore assume that the cost of the embankment alternative, (in values of early 1988, with 4% escalation during construction period, excluding electrical plant, powerlines and assuming a rate of 80 S.Sh per US dollar) shall be taken at about 196 million dollars.

Referring to the cost estimates prepared by ELC and taking into account the same items and financial assumptions as for the CIECC estimate, the cost of the RCC dam can be estimated at about 208 million dollars.

However, as recommended in our note of July 1988 (Contract Documents - volume 3 - Technical Specifications, comments by Pierre Londe) the RCC specifications should be relaxed (clauses 13.3, 13.7, 13.10.1, 13.12.2, 13.14.1, 13.16.2) resulting in significant cost savings. The unit price of RCC, for the dam as designed by ELC (low stresses, because of upstream batter, no requirements on watertightness because of separate impervious membrane on upstream face) will be lower than the unit price for conventional RCC.

The conclusion on cost estimates is that both alternatives are practically equivalent.

6.4 Tender Documents

Calling for both tenders simultaneously is recommended by the Panel, as the selection of one alternative and elimination of the other one would be arbitrary.

This procedure, which has not been often used in the past, is obviously desirable in a case like Baardhere where there are great difficulties for the owner to evaluate all the parameters listed in section 6.1 above and therefore to make a reliable comparison of both alternatives. The actual costs will be known when tenders are opened.

The Technical Committee of ICOLD on the Technology of Construction(*), has recently recommended to use the procedure of the double tender every time the decision to discard one of the alternatives is not obvious. Some large savings can be obtained by contractors who would evaluate the real costs differently from the Engineers.

(* Member countries: Australia, Austria, Brazil, Canada, China, France, Germany (FRG), Great Britain, Indonesia, Italy, Japan, Korea, USA, USSR, Yugoslavia.

Should the double tendering be used it is recommended to have common Tender and Contract Conditions, so as to enable the owner to make a balanced comparison of the costs, whereas Technical Specifications can be maintained different, as they are at the moment, even for items which are similar in both alternatives, such as reinforced concrete for example. Unifying the

Technical Specifications prepared by two distinct Consulting Engineers would not be practical.

APPENDIX A

LIST OF PARTICIPANTS

PANEL OF EXPERTS

1. Mr. Pierre Londe, Chairman
2. Dr. John Newbery
3. Mr. Ivor Pinkerton
4. Mr. Hans Bachmann

BDP

1. H.E. Minister Dr. Ahmed Habib Ahmed
2. Mr. Hussein Elabeh Fabriye
3. Mr. Mohamed Bashir Mohamud
4. Mr. Osman Sharif
5. Mr. Mohammad Saleem Sheikh

I.R.B.D

1. Mr. Aizad Nawaz Khan
2. Mr. Guy Lemoigne
3. Mr. Anthony Sparkes
4. Mr. Irfan Aleem

E.E.C.

1. Mr. Basile Papadopoulos
2. Mr. André Liebaert

CIECC

1. Mr. Zhang Zhenbang

ECC

1. Mr. Iyub Memon (part time)

APPENDIX B

LIST OF DOCUMENTS

FINAL REPORT

ATTACHMENTS (I, II III)

ANNEX I	: Geologic Report
ANNEX I-1	: Album of Core Samples
ANNEX I-2	: Logs of Boreholes and Pits
ANNEX II	: Field Investigations and Tests for Natural Building Materials
ANNEX III	: Laboratory Tests for Impervious Soils
ANNEX IV	: Report of Hydraulic Model Tests
ANNEX V	: Cost Estimation
ANNEX VI	: Drawings

VOLUME 1. Tender and Contract Documents

VOLUME 2. Tender Forms

VOLUME 3. Technical Specifications

VOLUME 4. Contract Drawings (same as Annex VI)

COST ESTIMATES (RCC Dam), December 1988